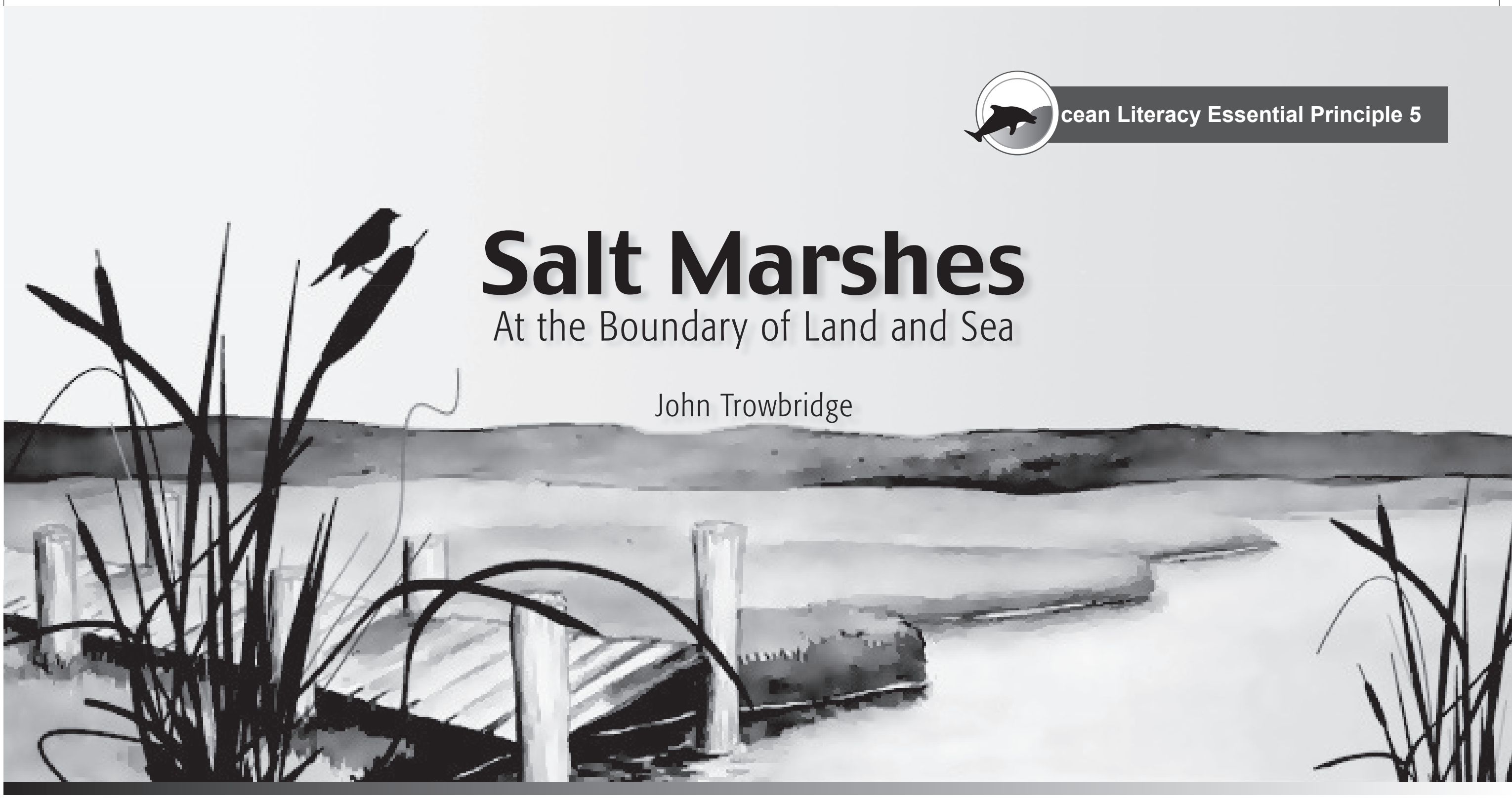
Ocean Literacy Essential Principle 5



Salt Marshes

At the Boundary of Land and Sea

John Trowbridge

Abstract. Estuaries are boundaries between freshwater from upland sources and seawater or water from a major lake. Within estuaries, marshes dominated by marsh grasses are unique ecosystems. An ocean-literate person understands that the grasses found in salt marshes are unique because of their ability to adapt to and tolerate saltwater, which is deadly to most plants. In the activity presented in this article, students have the opportunity to test 2 different species of plants for salt tolerance.

Keywords: estuary, primary production, salinity, salt marsh

An ocean-literate student understands that an estuary is the area where land meets a lake or, especially, the sea, where freshwater from upland sources such as rivers and stream meets seawater or water from a major body of water such a large lake (see the Appendix). This place of mixing bodies of water is colonized by special types of plants. In saltwater estuaries, the plant or grass species is *smooth cordgrass*, or *Spartina*, one of the few plant species that is adapted to and tolerates saltwater (see Figure 1). A goal of the activity presented in this article is the essential understanding of fundamental concepts and principles related to estuarine processes, salt marsh ecosystem, and changing salinities.

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Background

Estuaries are semienclosed bodies of water with a free connection to an open body of water, such as the ocean or a lake, whose water mixes with water from upland sources in the estuary. It may be simpler to say that estuaries are where freshwater and salt- or lakewater mix. An estuary is a transition zone between freshwater and marine or lake ecosystems. This area of water is a place of both physical mixing and chemical reactions and can be found in bays, lagoons, and tidal creeks. Estuaries are high in biological productivity and are important nursery areas for fish and shellfish.

The biological productivity of estuaries is higher than that of any farming areas on land. Net primary production—the storage of energy as an available food source through photosynthesis or chemosynthesis—in an estuary is comparable to coral reefs and tropical rain forests. There are several sources of primary productivity in estuaries: phytoplankton in the water column, benthic diatoms, marsh grasses, aquatic grasses, and mangroves.

Coastal areas are experiencing a tremendous loss of marshes and seagrass beds. For example, in the northern Gulf of Mexico, the land-loss rate is 24 square miles per year. The loss of marshes and seagrass beds means less primary production in the estuaries and, therefore, lower supplies of available energy (food or biomass) for higher trophic levels, including commercially important species of fish and shellfish.

The surrounding marshes found in estuaries are made up primarily of grasses, which form the basis of a detrital mill. Marsh grasses such as *Spartina* are annuals, so the

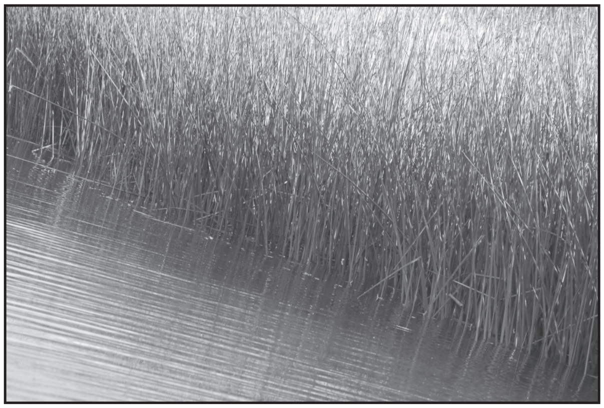

FIGURE 1. Special types of plants colonize estuaries.

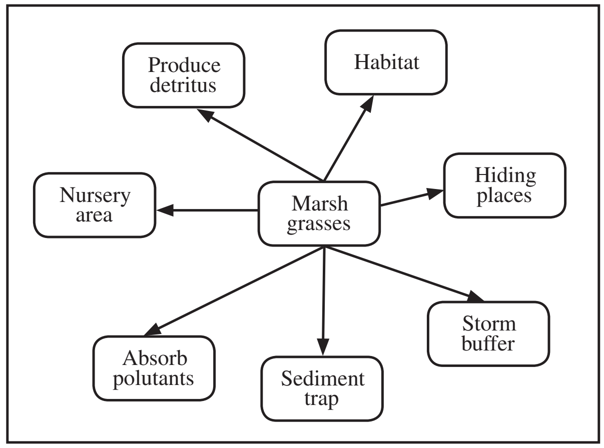

FIGURE 2. Functions of marsh plants.

above-ground plant dies every year. The dead plant material undergoes a decay process in which it breaks down continually into smaller pieces. As part of this process, the plant material becomes covered or enriched with bacteria and algae, which add to the nutritional value of the detritus. Detritus, like the primary producers, is an important food source found in estuaries. The increase in the amount of available food allows a larger number of animals to be supported in the habitat.

In addition to their role in primary and detrital production, marsh plants have many other functions (see Figure 2). These plants slow the flow of water through an estuary, trapping sediments and slowing sediment transport. This keeps nutrient-enriched water in the estuary for a longer period of time and slows the freshwater advance to the open body of water (the ocean or lake). The roots of marsh plants also anchor and stabilize the muddy substrate. These intertwined roots form a woven mat underground, which helps stabilize the muddy sediment. Also, plant litter from marsh plants contributes organic matter to the marsh soil, which enriches the soil and adds biomass. Finally, marsh plants offer storm protection by buffering and absorbing wave and wind energy before it can reach the mainland.

Estuaries are considered physically dominated systems in that the physical factors of salinity, temperature, turbidity, sediment, currents, tides, and winds determine what organisms live there. Organisms that occupy an estuary usually have high tolerances or special adaptations to deal with wide fluctuations in physical conditions. Many species minimize the physiological stresses by being temporary residents in the estuary and moving out during times of stress (Trowbridge 1994). These stressful fluctuations include the coming of day or night, high or low tide, or various seasons. Many animals use marshes as refuges from fluctuating conditions. Marsh grasses provide hiding places for the larval and young stages of many organisms, such as fish and shrimp. Thus, these grasses play a critical role in the ecology of estuaries.

Students can model one daily stress that organisms experience in an estuary: the fluctuation of salinity caused by changing tides. In this activity, students grow different grasses to represent a marsh and then test the various grasses by watering them with freshwater and seawater of different salinities. The saline water models high-tide conditions. This activity can be used in junior high and high school classes studying life science, environmental science, Earth science, and geography.

Procedure

Materials

- Six 2-L bottles
- Trays or tubs at least 2 cm deep
- Noniodine salt
- Jiffey Peat Pellets or similar product
- 250 g (½ lb) lawn grass seed
- 250 g (½ lb) salt-tolerant grass seed, such as Seashore Paspalum (If your local seed store does not have this product, it is available online from www.outsidepride .com.)
- Student science journals

Time Frame

You will need one 60-min class period to give the overview, prepare treatments, and soak the pellets. After treatment starts, you will need 15 min per class for 5–10 days.

Preparation

1. Fill two bottles with freshwater.
2. Fill two bottles with estuarine water of 15 parts per thousand of salt (15 g of salt per liter, or 30 g for the 2-L bottle).

3. Fill two bottles with saltwater of 30 parts per thousand (30 g of salt per liter, or 60 g for the 2-L bottle). Average ocean salinity is 35 parts per thousand. However, because we are modeling coastal waters, 30 parts per thousand is a good proportion to use.

Initiating Activity

Start with the following teacher-directed questions:

1. Can an animal that lives in a pond live in the ocean? Explain your answer.
2. Can an animal that lives in the ocean live in a pond? Explain your answer.
3. Can plants such as trees, bushes, and grasses live in saltwater?
4. What kind of plants, other than seaweed, can survive in or tolerate saltwater?

Directions and Treatment

As a class or in cooperative groups, students need to grow grass from seeds to a height of 2 cm. Have students follow these steps:

1. Soak 48 peat pellets in a tub of water overnight.
2. Plant 15 typical lawn grass seeds in each of 24 pellets, and plant the remaining 24 pellets with 15 salt tolerant grass seeds in each pellet. Place the pellets in separate trays.
3. Place the trays in strong light, and let the seeds grow until the grass culms (the blades of grass) reach 2 cm high. You do not need to water the pellets, but keep the bottom of the tray filled with about 1 cm of water. (The water will be wicked up to the grass seed.)
4. Divide the pellets with regular grass seed into three groups of eight, and place each group in a separate tray. Label tray 1 as *regular seed freshwater*, tray 2 as *regular seed estuarine water*, and tray 3 as *regular seed seawater*. Now do the same with the salt-tolerant seeds. Label tray 1 as *salt-tolerant seed freshwater*, tray 2 as *salt-tolerant seed estuarine water*, and tray 3 as *salt-tolerant seed seawater*. Double check to make sure all trays are correctly labeled.
5. Drain any water in the bottom of the trays.
6. Fill the bottom of tray 1 with freshwater, tray 2 with estuarine water, and tray 3 with saltwater. Try to keep the depth at 10 cm. It is important to use the same amount of water from each 2-L bottle. Add more water every few days if necessary to maintain a 10-cm depth.
7. Record daily measurements of grass height and appearance for 5–10 days. Students may use a chart like the one in Figure 3. (Typical lawn grasses will experience brown spots, yellowing, curling, and browning at very low levels of salinity, starting at 5 parts per thousand. The salt-tolerant grass will thrive at up to about 20 parts per thousand. At that point, the grass will begin to show signs of stress as described.)

Treatment	Day 1 average height*	Day 1 appearance**	Day 2 average height*	Day 2 appearance
Freshwater				
Estuarine water				
Saltwater				

*This is an excellent opportunity for students to decide how they want to calculate the average growth.
**Because these are qualitative data, students may record these observations in a journal. They should look for spotting, yellowing, and wilting.

FIGURE 3. Sample data recording chart.

Discussion and Findings

Students should prepare charts and graphs of grass growth over time and charts of observations such as spotting, yellowing, or wilting. To help students better understand their data, encourage thinking-out-loud discussion that uses the data to draw conclusions. For example, ask students to consider that tolerances have limits. At what salinity does the salt-tolerant grass die? Some organisms can tolerate a wide range of temperatures, whereas others can function only in a narrow range of temperatures; ask for examples. Another issue to consider is the use of salt-tolerant grasses for flood prevention. Many people support building seawalls to stop storm surges and prevent damage from expected rising sea levels. However, others suggest that extensive planting of salt-tolerant grasses would be better. Encourage students to write about conditions in the boundary zone between salt- and freshwater. Finally, ask students to consider the consequences of rising sea levels on coastal plants. Ask students to research the areas where tidal fluctuations are the greatest. Find out how many tidal cycles occur in 1 day on the east and west coasts of the United States and in the Gulf of Mexico. Discuss that a boundary may not be a narrow line, but rather a zone of transition such as salt marshes.

Extensions

To extend this activity, allow students to test different salinity regimes such as 5, 10, or 20 parts per thousand. Allow students to test other plants they think may be salt-tolerant. You may also wish to explore these questions as a class: Are there any projects in your state that are dedicated to salt marsh preservation or restoration? How do animals deal with changing salinities?

Conclusions

When students understand that the saline conditions of seawater create a hostile growing environment for plants, they may appreciate the importance of the few species of

plants that can survive at the boundary between saltwater and freshwater. Creating an ocean-literate citizenry that can understand such issues is necessary in light of the billions of dollars being spent on coastal projects and the likely rise in sea levels in the coming years.

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Appendix
Standards Addressed through the Present Activity

Principles of Ocean Literacy
1. The Earth has one big ocean with many features.
    - g. The ocean is connected to major lakes, watersheds and waterways because all major watersheds on Earth drain to the ocean. Rivers and streams transport nutrients, salts, sediments and pollutants from watersheds to estuaries and to the ocean.
5. The ocean supports a great diversity of life and ecosystems.
    - i. Estuaries provide important and productive nursery areas for many marine and aquatic species.

National Science Education Standards
- Science as Inquiry
    - Abilities necessary to do scientific inquiry
- Life Science
    - Characteristics of organisms
    - Organisms and environments
- Earth Science
    - Structure of the Earth system

Sources. Ocean Literacy: The Essential Principles of Ocean Sciences K–12 (National Geographic Society et al. 2006); and *National Science Education Standards* (National Research Council 1996).